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(54) **Title**: QUANTUM INFORMATION PROCESSING SYSTEM

(57) Abstract: A building block (1) for a quantum information processing system includes a superconducting qubit (2) having a Josephson junction (5) connected between two superconducting electrodes (3, 4). The two superconducting electrodes (3, 4) are coaxial and coplanar. The building block (1) also includes a control line (6) coupled to the superconducting qubit (2) and arranged to control the state of the superconducting qubit (2), and/or a readout element (8) coupled to the superconducting qubit (2) and arranged to measure the state of the superconducting qubit (2). The control line (6) and/or the readout element (8) are arranged out of plane with respect to the two superconducting electrodes (3, 4).

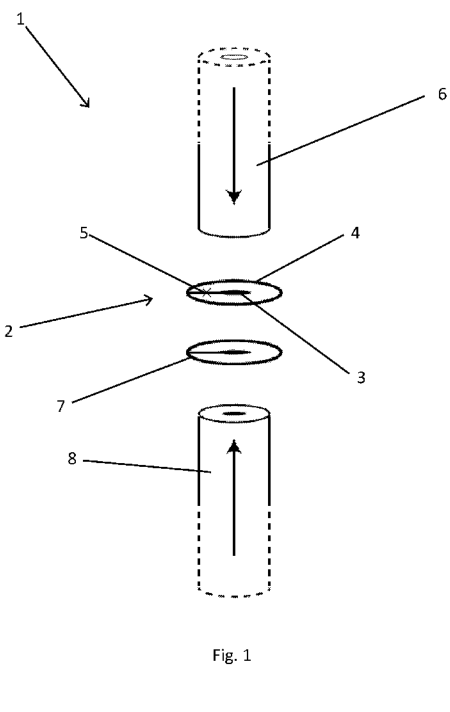

Fig. 1

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Quantum Information Processing System

This invention relates to quantum information processing systems and building blocks for such systems, in particular to superconducting building blocks for quantum information processing systems.

In a superconducting circuit implementation of a quantum computer, the base unit of quantum computing, a qubit (quantum bit), can be implemented physically in a number of different ways. Typically, one or more Josephson junctions are combined with capacitors and/or inductors, to form a high quality anharmonic circuit, the lowest quantised energy levels of which are used as the qubit. For example, a commonly implemented and successful design, known as a charge qubit or transmon, consists in its simplest form of a single Josephson junction in parallel with a capacitor. The two electrodes of the qubit can be arranged in a number of ways; examples include arranging the electrodes collinearly in a geometry reminiscent of a dipole antenna, or using interdigitated capacitors, or with one electrode in a cross shape, and the other realised as a common ground plane. Control and measurement circuitry is typically implemented using planar circuitry integrated on-chip with the qubits, and/or using 3D electromagnetic waveguides and cavities, in which the qubit chips are embedded.

An important consideration in the design of a quantum information processing system is to maximise the coherence time of the qubits (the lifetime of the fragile quantum states of the qubits that must be preserved to carry out the quantum computations). This requires a high level of control of the electromagnetic environment of the qubits, which needs to be engineered such that the qubits cannot easily leak their quantum information into it. A commonly implemented approach to achieve this environmental control is to embed the qubits within, or strongly couple them to, high quality electromagnetic resonators, either on-chip or in 3D, with resonant frequencies that are different from the qubit frequencies, thus preventing this energy leakage due to the inability of the environment to accept energy at the qubit frequencies. This approach, known as circuit quantum electrodynamics, also provides a convenient method of measurement of the quantum states of the qubits, since the resonators experience measurable frequency shifts when the qubits change their quantum states.

The macroscopic size of superconducting qubits makes it easy to couple control signals to the qubit, enabling fast operations to be performed relatively easy. However, a linear arrangement of the superconducting electrodes of a qubit typically mean that it couples strongly to the environment, particularly to electromagnetic fields that are homogeneous on the size scale of the qubit, which are often present in the environment. The result of this is that the coherence time of the quantum superposition state of the qubit, which is desired to be as long as possible in order to be able to perform quantum computations using the qubit, is reduced. This is because it is easy for the qubit to radiate energy when it is coupled to an electromagnetic field.

In order to perform any useful quantum computing, it is necessary to implement an architecture consisting of a large number of qubits, with couplings between them as well as wiring to enable control and readout of all (or a key subset) of the qubits. However, if such an architecture is implemented using in-plane couplings, and control and readout wiring, e.g. on the surface of a fabricated chip or circuit board, it becomes increasingly difficult with size to spatially accommodate the necessary wiring. This is because of the fundamental fact that the edges of a two-dimensional array of N qubits scales as the square root of N such that, for example, for a square arrange of M qubits by M qubits ($N=M^2$ qubits in total), control and readout lines of order M^2 need to be threaded through the edges (between the 4M edge qubits). This may hinder the implementation of a quantum computer of a practically useful scale having a 2D array of qubits.

This invention aims to provide an improved and scalable architecture for quantum computing systems.

When viewed from a first aspect the invention provides a building block for a quantum information processing system comprising:

a superconducting qubit comprising a Josephson junction connected between two superconducting electrodes, wherein the two superconducting electrodes are coaxial and coplanar;

a control line coupled to the superconducting qubit and arranged to control the state of the superconducting qubit; and/or

a readout element coupled to the superconducting qubit and arranged to measure the state of the superconducting qubit;

wherein the control line and/or the readout element are arranged out of plane with respect to the two superconducting electrodes.

When viewed from a second aspect the invention provides a quantum information processing system comprising a plurality of building blocks as recited in the first aspect of the invention;

wherein at least some (and preferably all) of the superconducting qubits in the plurality of building blocks are coupled to one or more of the other of the superconducting qubits in the plurality of building blocks.

The present invention relates to a quantum information processing system in which a superconducting qubit is provided as a basic building block. The superconducting qubit is formed from a Josephson junction connected between two coaxial and coplanar superconducting electrodes, i.e. the weak link of the Josephson junction, e.g. a barrier of insulating material, is provided between the two coaxial and coplanar superconducting electrodes. The Josephson junction combined with the capacitance between these electrodes implements a charge qubit, or Transmon (in the case that the Josephson energy is much larger than the charging energy associated with the capacitance).

Coupled to the superconducting qubit is preferably a control line which is arranged to control the quantum state of the individual qubit, e.g. by exposing the qubit to a microwave pulse of controlled amplitude and phase. This control line may also be used in the implementation of multi-qubit operations in a multi-qubit system, e.g. as outlined in the second aspect of the invention. Also preferably coupled to the superconducting qubit is a readout element which is arranged to measure the quantum state of the superconducting qubit, e.g. during or after quantum computations, in the implementation of quantum algorithms, or to learn the result of a quantum computation. The control line and/or the readout element are arranged out of plane with respect to the plane of the two superconducting electrodes of the qubit, i.e. these elements are provided at a position which does not lie in the same plane as that two superconducting electrodes.

The invention also extends to a quantum information processing system which includes multiple building blocks, with each building block being coupled, i.e. electromagnetically, to at least one of the other building blocks in the system.

The Applicant has recognised that by providing a building block for a quantum information processing system in which the superconducting qubit has coaxial electrodes, this helps to significantly reduce the electromagnetic coupling of the qubit to uniform electromagnetic fields compared to a qubit having a linear geometry, because the electrodes of the qubit do not lie along a single direction, i.e. they are coaxial, e.g. having a circular symmetry. The qubit may couple to electromagnetic fields having a coaxial components or a substantial field gradient at the location of the qubit; however these fields are much less likely to be naturally present in the qubit’s environment. Thus the qubit is isolated effectively from the electromagnetic environment, helping to increase the coherence time of the qubit.

Furthermore, because the far field radiation of a qubit with coaxial electrodes decreases very rapidly at distances larger than the size of the qubit, the qubit couples only very weakly, if at all, to other electromagnetic objects in the system, e.g. other qubits, in addition to the isolation from the electromagnetic environment as described above. This electromagnetic isolation again helps to increase the coherence time of the qubit, as well as improving the practicality of a building a large-scale multi-qubit system. This compares to a conventional qubit with a linear configuration that typically has a large dipole moment and provides a far more significant electromagnetic field at large distances from the qubit.

The Applicant has also recognised that by providing a building block for a quantum information processing system in which the control and readout elements are arranged out of plane with respect to the plane of the two superconducting electrodes of the qubit, the topology of a quantum information processing system comprising a plurality of building blocks is able to scale in the same way as the number of building blocks. This is because although a plurality of couplings are provided to the qubit, as the control and readout elements are arranged out of plane with respect to the electrodes of the qubit they do not require any space to be provided for them in the plane of the electrodes. It will be appreciated that the same is not possible for conventional quantum computing systems, e.g. implemented using in-plane geometry, as all of the components and connections have to be provided in the same plane, which becomes increasingly difficult as the system has more than a few qubits.

The two superconducting electrodes of the qubit may be arranged in any suitable and desired coaxial and coplanar configuration. In a preferred embodiment the two superconducting electrodes of the qubit are radially symmetric, i.e. circular. This configuration of the two electrodes even further helps to reduce the electromagnetic coupling of the qubit to the environment, because there is no direction in the plane of the electrodes in which the electrodes are oriented more than other directions. The outer of the two coaxial superconducting electrodes may comprise a ground plane, e.g. shared with other qubits when the system comprises a plurality of qubits.

The superconducting electrodes may be continuous, e.g. in a circle. However in one embodiment the outer of the two electrodes is discontinuous, e.g. at a (single) point. Thus there may be a small gap in the outer ring electrode of the qubit. This helps to prevent persistent circulating currents and trapped magnetic flux between the two superconducting electrodes.

The qubit may be formed in any suitable and desired manner. In a preferred embodiment the qubit, i.e. including the two superconducting electrodes and the weak link, is formed using micro-fabrication of low loss superconducting materials, such as aluminium, on a low loss dielectric substrate, such as sapphire or silicon.

In one embodiment the qubit is arranged to be frequency tuneable, e.g. by incorporating two Josephson junctions connected in parallel between the two superconducting electrodes and an out-of-plane control line that controls the magnetic flux which threads the gaps enclosed by the superconducting electrodes and the Josephson junctions. This embodiment enables implementation of control operations that require frequency tuneable qubits.

The control line of the building block may be provided in any suitable and desired manner. In a preferred embodiment the control line is arranged coaxially with the two superconducting electrodes of the qubit. Additionally or alternatively the control line comprises a coaxial cable, e.g. having a geometry matching or similar to the coaxial electrodes of the qubit. This arrangement enables the control line to be coupled to the qubit in a straightforward manner and to control a single qubit highly selectively from a plurality of qubits in a multi-qubit system.

In another embodiment the control line comprises a magnetic flux control line. Such a magnetic flux control line preferably comprises a coaxial line with an electrically shorted end, wherein the coaxial line has a central conductor connected to an outer ground conductor, e.g. in a manner that enables currents in the coaxial cable to produce a magnetic flux in the nearby qubit. This allows the control line to control the frequency of the qubit, e.g. in the embodiment in which the qubit is frequency tuneable.

The control line is arranged to control the state of the qubit in any suitable and desired manner. Preferably the control line is arranged to radiate the qubit with electromagnetic radiation, e.g. with microwaves. In a preferred embodiment the control line is arranged to apply a pulse of electromagnetic radiation (e.g. microwaves) to the qubit. The length, phase and/or amplitude of the pulse of electromagnetic radiation may be varied to implement universal single qubit control. Thus preferably the control line is arranged to provide universal control of the quantum state of the qubit.

The readout element of the building block may be provided in any suitable and desired manner. In a preferred embodiment the readout element comprises a, e.g. microwave, resonator coupled to the superconducting qubit, e.g. arranged coaxially with the two superconducting electrodes of the qubit. The microwave resonator may comprise a lumped element microwave resonator, e.g. having the same geometry as the qubit and only differing by the use of a linear inductor in place of the Josephson junction. Therefore, in a particularly preferred embodiment, the two superconducting electrodes, the control line and/or the readout element are arranged coaxially. Additionally or alternatively the readout element comprises a coaxial cable, e.g. having a geometry matching or similar to the coaxial electrodes of the qubit. This arrangement enables the readout element to be coupled to the qubit in a straightforward manner and to perform highly selective measurement of a single qubit from a plurality of quits in a multi-qubit system.

The readout element is arranged to measure the state of the qubit in any suitable and desired manner. In a preferred embodiment (when the readout element comprises a coaxial cable and microwave readout resonator), the coaxial cable of the readout element is arranged to measure the response of the readout microwave resonator (that is coupled to the qubit), e.g. at a certain frequency, from which the state of the qubit may be inferred.

In one embodiment of the building block, the control line and readout element may be formed as a single element, i.e. combined into the same element, preferably comprising a coaxial cable and a coaxial readout resonator, which is arranged for both single qubit control and measurement, e.g. with the coaxial cable arranged behind the readout resonator.

In the quantum information processing system, preferably each control line and/or readout element is only coupled to a single qubit, i.e. preferably there is a one to one relationship between a qubit and its associated control line and/or readout element. The quantum information processing system may be provided such that not all qubits have an associated control line and/or readout element, e.g. to implement a particular quantum computing architecture such as the surface code.

In the quantum information processing system, each of the plurality of building blocks can be coupled to one or more of the other of the plurality of building blocks in any suitable and desired manner. In a preferred embodiment one or more, and preferably all, of the plurality of building blocks are coupled to the nearest other building block to them. Coupling building blocks to their nearest neighbour(s) helps to provide a simple scalable architecture which may be capable of implementing fault tolerant quantum computing schemes such as the surface code.

Preferably the coupling comprises a capacitance between the outer electrodes of adjacent qubits, e.g. whose capacitance can be adjusted by changing the geometry and/or spacing of the qubit electrodes. Preferably the quantum information processing system further comprises one or more additional superconducting qubits, which may be connected to one or more of the building blocks in any suitable and desired way, such as via capacitances between the outer electrodes of adjacent qubits. For example, the additional superconducting qubits may or may not be connected to control lines and/or readout elements.

The plurality of building blocks in the quantum information processing system may be arranged in any suitable and desired way. In a preferred embodiment the building blocks are arranged in a, e.g. regular, array. The type of array may depend on the number of other building blocks to which each building block may be desired to be coupled. For example the array may comprise a square array (i.e. with the qubits arranged in rows and columns), in which case each qubit may be coupled to up to four other qubits (assuming, for example, that only nearest neighbour couplings are used). In another embodiment the array may comprise a triangular array, in which case each qubit may be coupled to up to six other qubits (assuming, for example, that only nearest neighbour couplings are used). In another embodiment the array may comprise a hexagonal array, in which case each qubit may be coupled to up to three other qubits (assuming, for example, that only nearest neighbour couplings are used). Other geometries may be used as is suitable and desired.

The plurality of qubits in the quantum information processing system may be provided in a single plane, i.e. the plane of the superconducting electrodes. However embodiments are also envisaged in which multiple planes of qubits are provided, e.g. stacked on top of each other such that the planes of qubits are parallel.

The quantum information processing system may comprise any suitable and desired number of qubits. In one embodiment the quantum information processing system comprises 10 or more qubits, e.g. 20 or more qubits, e.g. 50 or more qubits, e.g. 100 or more qubits.

In one embodiment the quantum information processing system comprises processing circuitry arranged to operate on one or more of the plurality of qubits, e.g. to manipulate the state of the one or more qubits. Preferably the processing circuitry is arranged to implement one or more, e.g. high fidelity single and two-qubit, quantum logic gates throughout the qubit array in the system. Also preferably the processing circuitry is arranged to implement high fidelity single shot qubit measurement on at least a subset of the qubits in the array. Also preferably the processing circuitry is arranged to implement one or more error correction schemes, e.g. using feedback algorithms. This enables the quantum information processing system to perform useful quantum computations.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a building block for use in a quantum information processing system according to an embodiment of the present invention;

Figure 2 shows a group of the building blocks as shown in Figure 1;

Figures 3 and 4 show an array of the building blocks as shown in Figure 1; and

Figure 5 shows a building block for use in a quantum information processing system according to a further embodiment of the invention.

Figure 1 shows schematically a building block 1 for use in a quantum information processing system according to an embodiment of the present invention. The building block 1 includes a superconducting qubit 2 having two superconducting electrodes 3, 4 and a Josephson junction 5 between the two superconducting electrodes 3, 4. The two superconducting electrodes 3, 4 are arranged as a circular inner superconducting electrode 3 which is surrounded by a coaxial and coplanar circular outer superconducting electrode 4. The Josephson junction 5 is arranged to extend radially between the two superconducting electrodes 3, 4. The superconducting qubit 2 may be formed using micro-fabrication of low loss superconducting materials, such as aluminium, on a low loss dielectric substrate, such as sapphire or silicon.

In order to control the quantum state of the superconducting qubit 2, a control line 6 is provided coaxially with the superconducting qubit 2. The control line 6 is arranged to radiate the superconducting qubit 2 with microwaves in order to set the state of the superconducting qubit 2.

On the other side of the superconducting qubit 2 is provided a readout resonator 7 and a readout line 8, both of which are also arranged coaxially with the superconducting qubit 2. The readout resonator 7 is arranged to couple to the superconducting qubit 2 in such a way that its resonant frequency is dependent on the state of the superconducting qubit 2. The readout line 8 is arranged to radiate the resonator 7 and measure the frequency shift of the resonator 7 and thus the state of the superconducting qubit 2 via the reflected microwave signal.

Figure 2 shows schematically a group 10 of three of the building blocks 1 as shown in Figure 1, arranged in a straight line. The superconducting qubits 2 all lie in the same plane and thus can be formed on the same substrate. The resonators 7 can be formed on the reverse side of the same substrate, or on a separate substrate. As will be shown with reference to Figure 4, though not shown in Figure 2, the outer superconducting electrode 4 of each superconducting qubit 2 is connected via a capacitor to the outer superconducting electrode 4 of the nearest neighbouring qubit 2.

Figure 3 shows schematically a group 20 of nine of the building blocks 1 as shown in Figure 1, arranged in a square array. The superconducting qubits 2 all lie in the same plane and thus can be formed on the same substrate. The resonators 7 can be formed on the reverse side of the same substrate, or on a separate substrate. As will be shown with reference to Figure 4, though not shown in Figure 3, the outer superconducting electrode 4 of each superconducting qubit 2 is connected via a capacitor to the outer superconducting electrode 4 of the nearest neighbouring superconducting qubit 2.

Figure 4 shows schematically a plan view of the building blocks 1 shown in Figure 3. As can be seen, the building blocks 1 are arranged in a square array with the outer superconducting electrode 4 of each superconducting qubit 2 being connected via a capacitor 9 to the outer superconducting electrode 4 of the nearest neighbouring superconducting qubit 2.

In addition, to implement the quantum information processing system including the building blocks 1 as shown in Figures 1 to 4, the system will include a number of standard control electronics (not shown), e.g. connected to the end of each of the coaxial cables, e.g. including the control lines 6 and readout lines 8, as well as a suitable cooling system (not shown) required to keep the necessary components at a superconducting temperature.

In operation the quantum information processing system 10 or 20 is provided as part of a quantum computer, for example. The control lines 6 apply a pulse of microwave radiation to their respective superconducting qubits 2, the length, phase and/or amplitude of which is used to control the state of the superconducting qubits 2, i.e. the state of the qubit, and perform single qubit operations. Multiqubit (e.g. two-qubit) quantum logic operations are implemented in any desired manner, e.g. by applying appropriate microwave pulses to the control lines 6, making use of the capacitive or otherwise coupling between qubits. The quantum state of the superconducting qubits 2 is thus manipulated by a sequence of quantum logic gates to perform computations using the quantum information processing system 10 or 20.

Once the computations have been performed, the readout resonators 7 are used to measure the state of their respective superconducting qubits 2, e.g. by measuring the amplitude and/or phase of a microwave signal applied to readout lines 8, radiating the readout resonators 7 close to their resonant frequency, which is dependent on the state of their respective superconducting qubit 2.. The state of the superconducting qubits 2 after the computations have been performed can then be used to determine the result of the computations.

Figure 5 shows schematically a building block 21 for use in a quantum information processing system according to a further embodiment of the invention. The building block 21 of this embodiment is similar to the building block shown in Figures 1 to 4, i.e. it includes a superconducting qubit 22 having two superconducting electrodes 23, 24 that are arranged as a circular inner superconducting electrode 23 which is surrounded by a coaxial and coplanar circular outer superconducting electrode 24.

The difference is that the superconducting qubit 22 comprises two Josephson junctions 25, 26 which extend radially between the two superconducting electrodes 23, 24. This renders the superconducting qubit 22 flux tuneable, i.e. it’s transition frequency can be tuned by altering the magnetic flux threading the two spaces between the two electrodes of the superconducting qubit 22.

The control line 27 is provided coaxially with the superconducting qubit 22 and is able to provide magnetic flux control to the superconducting qubit 22. The readout resonator 28 and a readout line 29 are provided on the opposite side of the superconducting qubit 22 and the readout line 29 is also used as a control line for implementation of single qubit control which, in the embodiment shown in Figure 1, is achieved using the control line 6.

As with the building block shown with reference to Figures 1 to 4, the building block 21 of Figure 5 is arranged as part of an array of building blocks to form a quantum information processing system.

The operation of the building block 21 shown in Figure 5 (as part of a quantum information processing system) is similar to the building block shown in Figures 1 to 4, i.e. the control line 27 is arranged to set the quantum state of the superconducting qubit 22 by applying a magnetic flux to the superconducting qubit 22. The state of the building block 21 (along with others in the quantum information processing system) is then manipulated and subsequently measured using the readout resonator 28 and readout line 29.

Thus it will be appreciated that the building block and quantum information processing system of the present invention help to significantly reduce the electromagnetic coupling of the building block to uniform electromagnetic fields compared to a superconducting qubit having a linear geometry, because the superconducting electrodes of the superconducting qubit do not lie along a single direction. Thus the building block is isolated effectively from the electromagnetic environment, which helps to increase the coherence time of the qubit.

It will also be appreciated that by providing a building block for a quantum information processing system in which the control line and readout element are arranged out of plane with respect to the plane of the two superconducting electrodes of the superconducting qubit, the topology of a quantum information processing system comprising a plurality of building blocks is able to scale in the same way as the number of building blocks (qubits).

Claims

1. A building block for a quantum information processing system comprising:

a superconducting qubit comprising a Josephson junction connected between two superconducting electrodes, wherein the two superconducting electrodes are coaxial and coplanar;

a control line coupled to the superconducting qubit and arranged to control the state of the superconducting qubit; and/or

a readout element coupled to the superconducting qubit and arranged to measure the state of the superconducting qubit;

wherein the control line and/or the readout element are arranged out of plane with respect to the two superconducting electrodes.

2. A building block as claimed in claim 1, wherein the outer of the two superconducting electrodes comprises a ground plane.

3. A building block as claimed in claim 1 or 2, wherein the two superconducting electrodes of the superconducting qubit are radially symmetric.

4. A building block as claimed in any one of the preceding claims, wherein the superconducting qubit is arranged to be frequency tuneable.

5. A building block as claimed in any one of the preceding claims, wherein the control line is arranged coaxially with the two superconducting electrodes of the superconducting qubit.

6. A building block as claimed in any one of the preceding claims, wherein the control line comprises a magnetic flux control line.

7. A building block as claimed in any one of the preceding claims, wherein the control line is arranged to provide universal control of the quantum state of the superconducting qubit.

8. A building block as claimed in any one of the preceding claims, wherein the control line is arranged to radiate the superconducting qubit with electromagnetic radiation.

9. A building block as claimed in any one of the preceding claims, wherein the control line is arranged to apply a pulse of electromagnetic radiation to the superconducting qubit.

10. A building block as claimed in any one of the preceding claims, wherein the readout element is arranged coaxially with the two superconducting electrodes of the superconducting qubit

11. A building block as claimed in any one of the preceding claims, wherein the two superconducting electrodes, the control line and/or the readout element are arranged coaxially.

12. A building block as claimed in any one of the preceding claims, wherein the readout element comprises a resonator coupled to the superconducting qubit.

13. A building block as claimed in any one of the preceding claims, wherein the control line and the readout element are formed as a single element.

14. A quantum information processing system comprising plurality of building blocks as claimed in any one of the preceding claims;

wherein at least some of the plurality of building blocks are coupled to one or more of the other of the plurality of building blocks.

15. A system as claimed in claim 14, further comprising one or more additional superconducting qubits.

16. A system as claimed in claim 15, wherein one or more of the additional superconducting qubits are coupled to one or more of plurality of building blocks.

17. A system as claimed in claim 14, 15 or 16, wherein each control line is only coupled to a single superconducting qubit.

18. A system as claimed in any one of claims 14 to 17, wherein each readout element is only coupled to a single superconducting qubit.

19. A system as claimed in any one of claims 14 to 18, wherein one or more of the plurality of building blocks are coupled to the nearest other building block to them.

20. A system as claimed in any one of claims 14 to 19, wherein the coupling between building blocks comprises a capacitor.

21. A system as claimed in any one of claims 14 to 20, wherein the building blocks are arranged in an array.

22. A system as claimed in any one of claims 14 to 21, further comprising processing circuitry arranged to operate on one or more of the plurality of building blocks.

23. A system as claimed in claim 22, wherein the processing circuitry is arranged to implement one or more quantum logic gates.

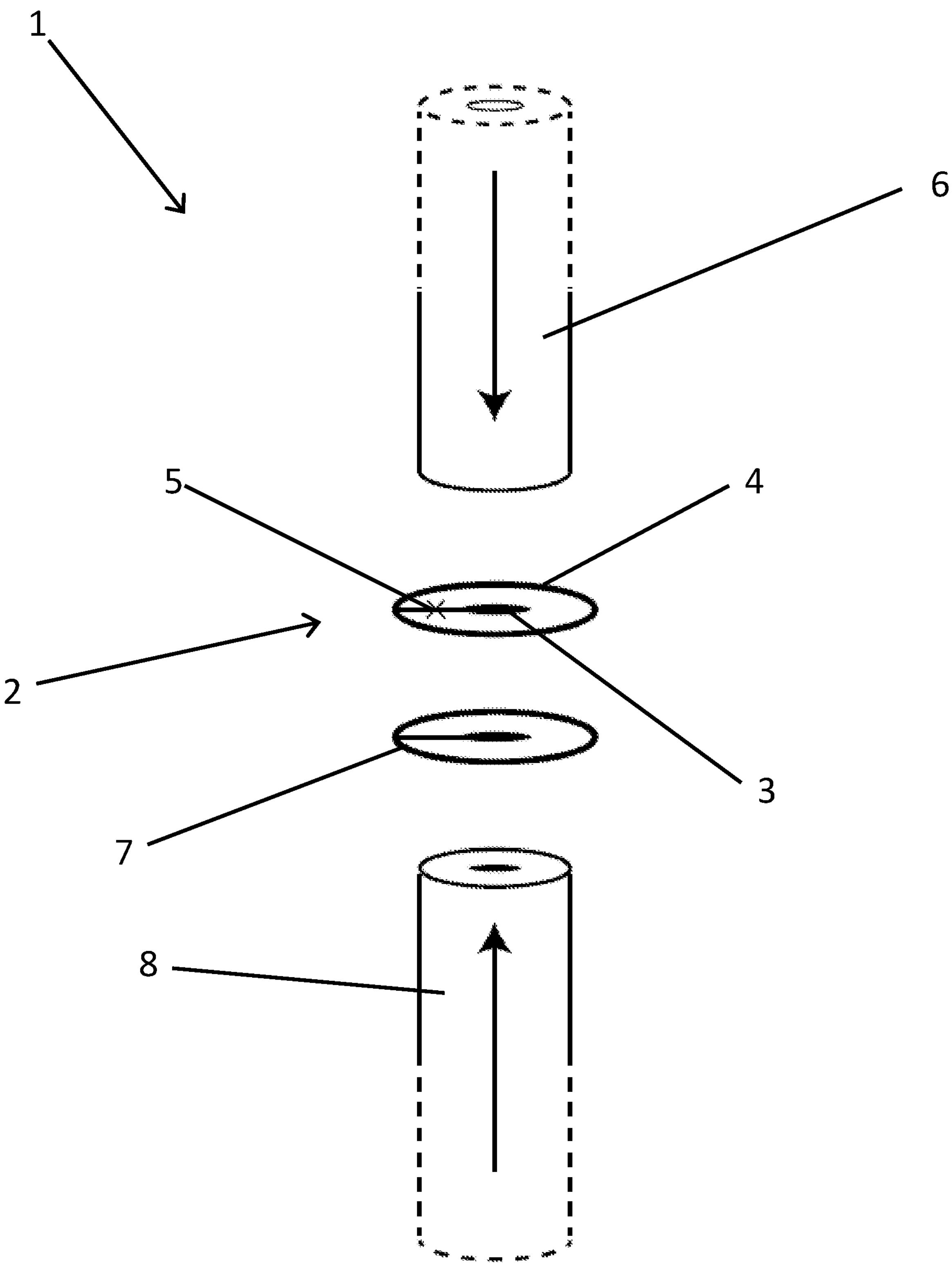

Fig. 1

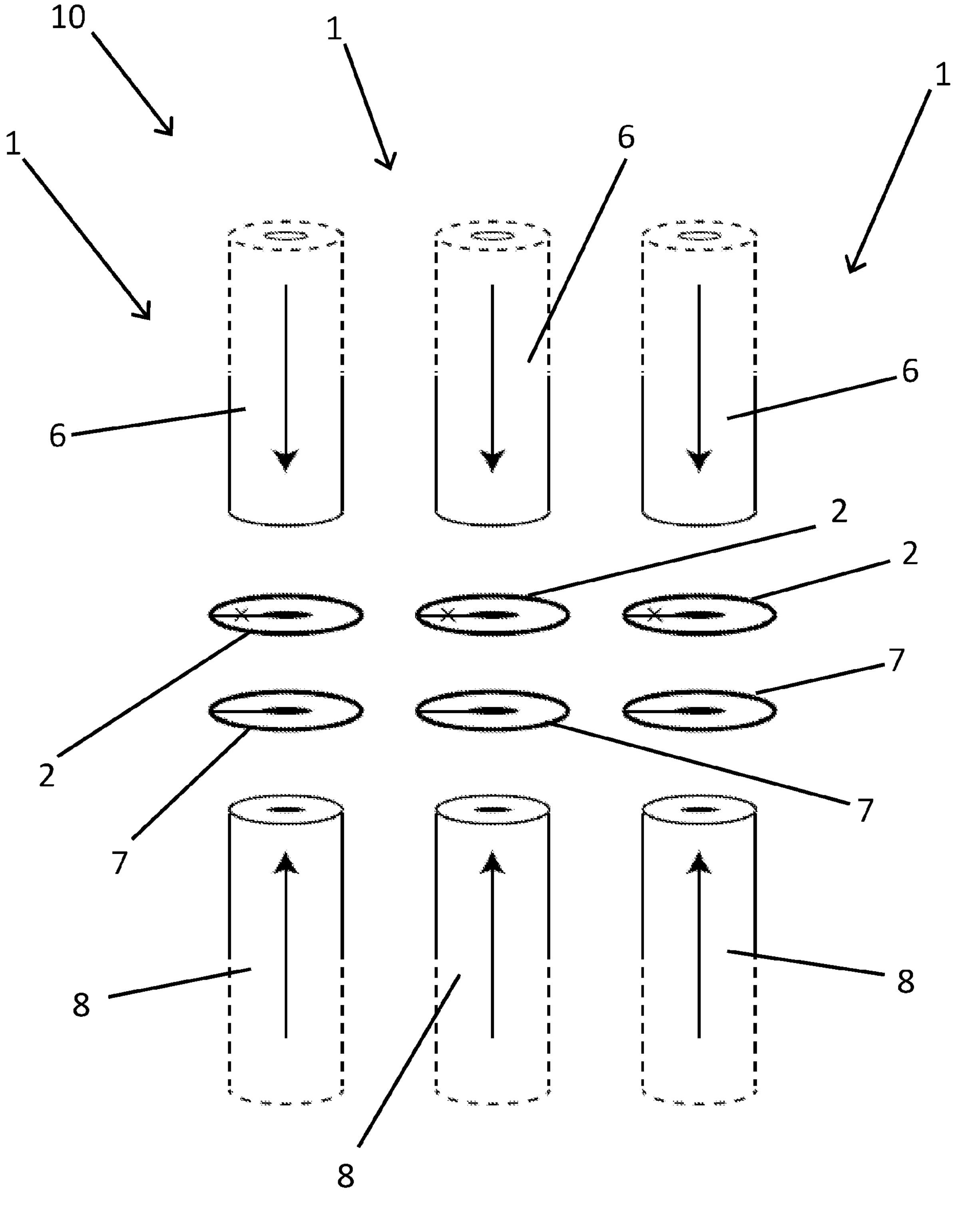

Fig. 2

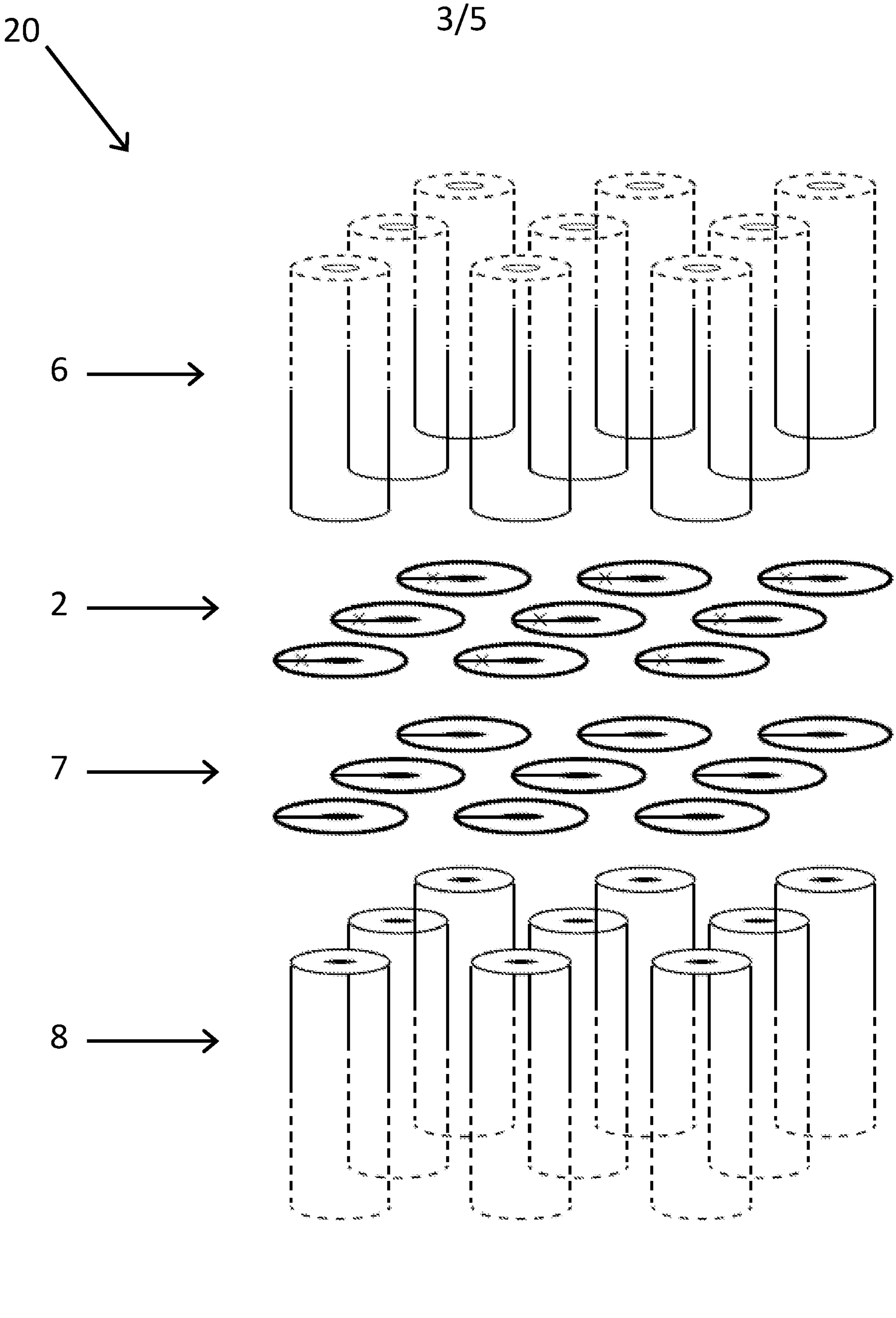

Fig. 3

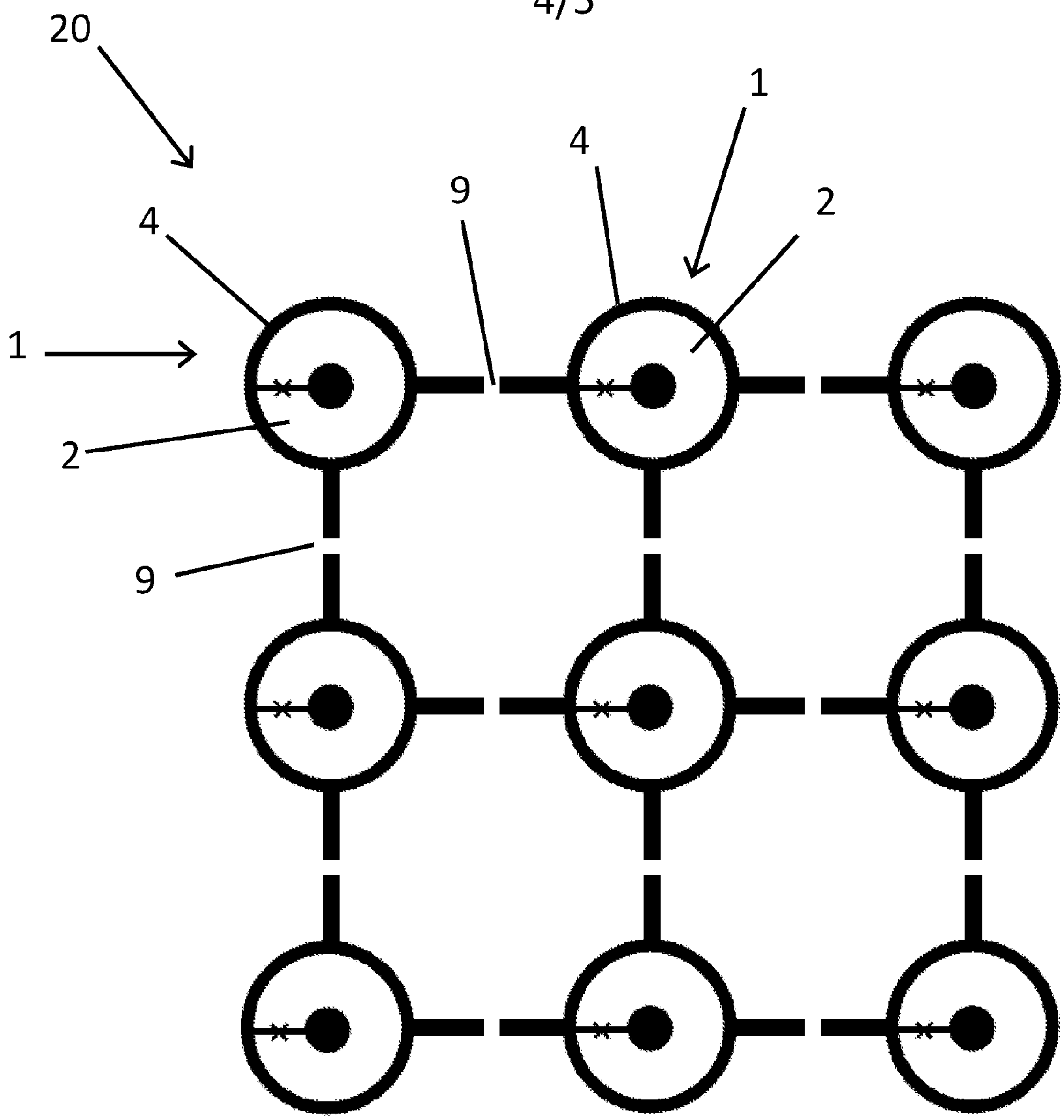

Fig. 4

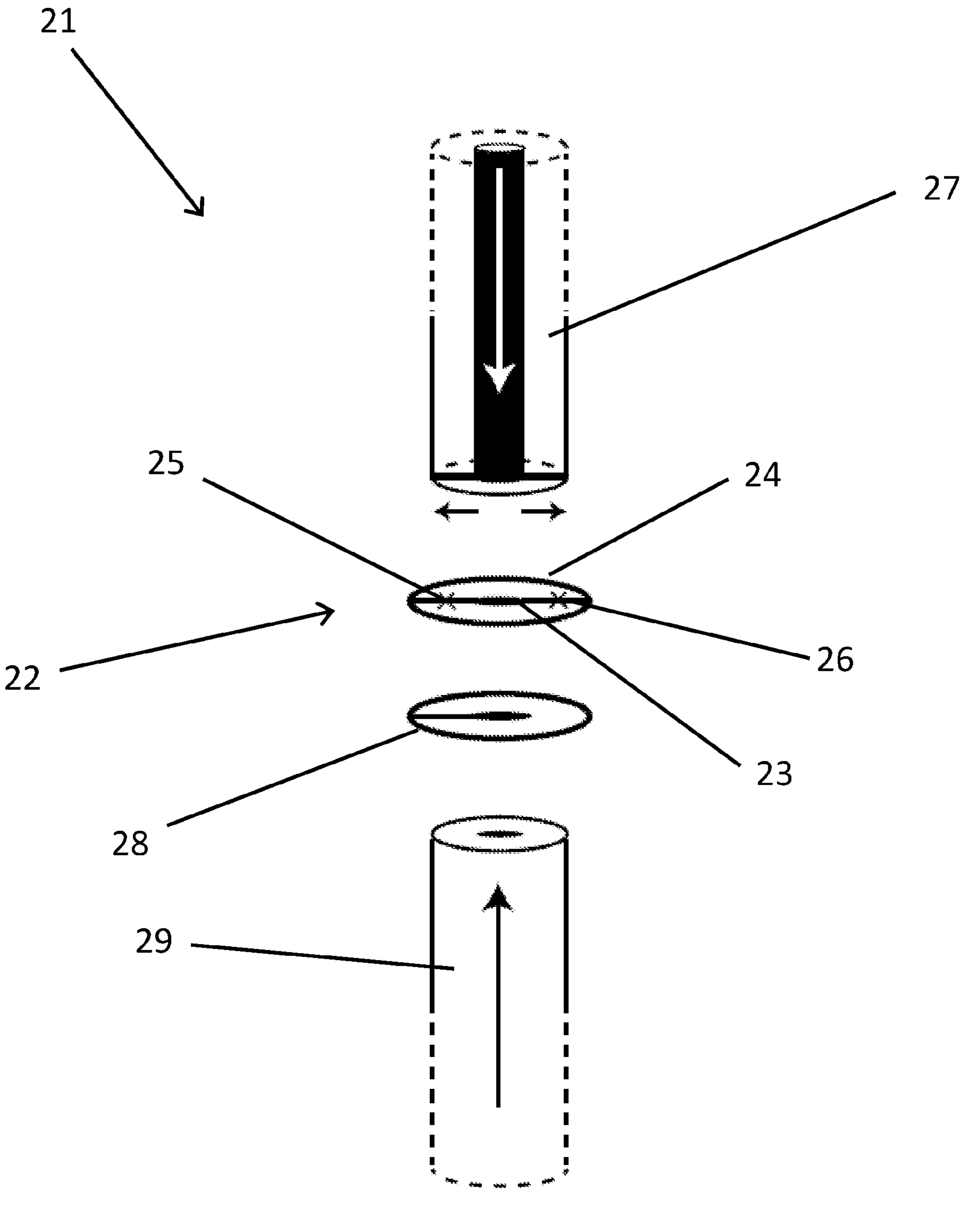

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2016/052350

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06N99/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Martin P Weides ET AL: "Multiphoton dressing of an anharmonic superconducting many-level quantum circuit", 2015 Quantum Metamaterials Workshop QMM Spetses, 4 June 2015 (2015-06-04), page 1, XP055312277, Retrieved from the Internet: URL:https://qcn.physics.uoc.gr/qmm2015/sites/files/qmm2015/Weides_QMM_Spetses-1.pdf [retrieved on 2016-10-19] Slides 5,15-18,21-25,28 ----- -/--	1-23

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
20 October 2016	27/10/2016

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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